Idaho National Engineering and Environmental Laboratory

Development of a 3-Dimensional Version of the Millsoft Simulation Software

Today's high capacity semiautogenous grinding (SAG) mills expend vast amounts of energy, and in doing so consume tons of steel balls, as well as shell liners, while processing ore. A considerable amount of this energy is expended on unwanted ball strikes on the mill shell. The causes of these energy inefficiencies in SAG mills are the least understood. The harsh environment of the interior of the mill prevents any instrumentation from being placed there. A 2D software simulation code has been developed which shows exactly the motion of the charge in the SAG mill. Using the test code, an operating mill substantially increased production while significantly reducing consumption of grinding balls. One proposed project at the INEEL is to develop a 3D simulation code to more fully describe the interactions of the end-lifters, shell-lifters, and ball charge in the SAG mill. This technology will alone bring about a major improvement in energy efficiency in SAG mills.

Statement of Problem and Technology Concept

Today's semiautogenous mills have a capacity of 2,500 to 6,000 tons per hour, consume 3-7 kWh/ton of energy, and in the process, wear out 1-1.5 lb of steel balls per ton of ore processed. On a longer term, steel is also consumed as shell lifters and liners wear out over a period of 6-12 months.
The causes of energy in-efficiency of SAG mills are least understood. At best, each mine site engineers a good operating philosophy based on past experience. Yet, one can listen to the operating SAG mill and intuitively discern that numerous balls strike the shell or lifters, in effect 30% of the energy is wasted in metal-to-metal collisions. However, operators keep the noise level of the operating mill high enough to produce enough grinding action in the belly of the mill. Thus, mill capacity is maintained at the expense of increased metal wear and electrical energy is expended on unwanted ball strikes on the mill shell. At this time, there are no instruments whatsoever that can survive the harsh environment in the mill, yet shed some light on the motion of charge in the mill. A group of researchers at the INEEL have developed a simulation code called Millsoft, which shows exactly the motion of charge in SAG mills. When this code was first tested at an Argentinean mine, the simulator suggested using a 48- lifter configuration instead of the usual 72-lifter configuration for this 36-foot mill. The mine site increased production from 45,000 tons/day to 85,000 tons/day. At the same time, the consumption of ball charge decreased by 25%, which represents a saving of 10 tons of balls or US$ 5,000 each day. To simplify the numerical calculations, the code uses a 2D approach, i.e., a thin section of the mill, as wide as the largest ball for simulation. The research team proposes to develop a fully three dimensional (3D) simulation code. This new code will show internal ball and charge classification along the length of the mill. It will show the combined effect of end-lifters and shell-lifters on charge motion. Due to internal classification in the SAG mill, it turns into a fully autogenous mill at the first one-third of the mill length, a true SAG mill at the middle one-third, and a ball mill in the last one-third. With the proposed code, the inefficiency due to internal classification will be quantified and newer designs of shell lifters to disrupt classification will be developed. Thus the 3D code incorporates what has been learned with 2D code and extends the capability further. This technology alone will bring about a major increase in energy efficiency and considerably reduce or even eliminate critical size formation too common in SAG mills. Next, the

consumption of steel balls in daily production and loss of lifters in the long-term is a major cost entity in SAG operation. With the proposed code, one can quantify steel consumption readily for a given mill design and operating speed. Thus, mine sites can study the economic picture for months of operation just by simulation. In effect, the code is a much more realistic simulation of plant SAG mills. Hence, parallel processing and a cluster of computers would be used.

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